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WELL DEVELOPMENTS

No. VII Board of Water Well Contractors November 1989

PLEASE RETURN

Application Deadline For Monitoring Well Constructor's License Without Examination

All applicants for the monitoring well constructor's license who wish to obtain the license without examination must apply before December 31, 1989. For current water well contractors who have not applied, the application must be submitted with the $110 fee and verification that the water well contractor's bond also covers monitoring well construction.

All other applicants must submit the application, the $110 fee, a listing of one year of experience in the monitoring well industry within the past four years, and a bond.

For applications, contact the Board of Water Well Contractors office in Helena at (406) 444-6643.

Surface Grouting

Recent well log reports and a field investigation have shown that some water well contractors are not grouting the top 6 to 8 feet of the drill hole when a pitless adaptor is to be installed.

This practice was discussed by the Board of Water Well Contractors at meetings in April and September of this year. The Board's decision was that ARM 36.21.654 (3) will not be changed, and all wells must be grouted to the top of the ground surface. Without the surface grout, there is no way to determine if the well was grouted at all. Another concern is that, if installation of the pitless adaptor is delayed, surface water could enter the well. The determination of the Board was that this practice does not provide adequate protection of the well or the aquifer into which the well has been drilled.

For those of you who feel strongly that this rule should be changed, you can petition the Board for a rule change. In the meantime, this practice will be considered a violation of the minimum water well construction standards and could subject violators to disciplinary action.

Survey Results

You may recall that in the April issue of the newsletter, a survey card was included for you to complete and return to the Board office.

Approximately 300 cards were mailed. Thirty-four were returned. Eight of these were returned by contractors or drillers. Twenty-six were returned by monitoring well constructors, sanitarians, city, state, or federal employees, geologists, hydrogeologists, geotechnical engineers, consulting engineers, and a drilling mud expert.

Suggestions were made for future newsletter articles. Some of the suggestions were: peforations above the static water level, abandoned wells and safety, decommissioning wells, aquifer tests, casing bedrock wells, particularly fractured systems in developed areas with minimal septic system inspection and treatment, and case studies in monitoring well design and its importance on construction and bacteriological quality.

If you were one of those individuals who did not return the survey card and you still have it, please take a minute to complete it and drop it in the mail.

Public Water Systems

In the October 1987 Well Developments, an article was included that discussed the need to apply to the Department of Health and Environmental Sciences (DHES) for review and approval of the specifications for a public well **prior to construction** of the wells. When a water well contractor is hired to drill a well that may be considered a public well, he should be sure that the owner is properly informed of the review and approval requirements of DHES. A public water system is defined as:

> A system for the provision of water for human consumption from any community wells, water hauler for cisterns, water bottling plant, water dispenser, or other water supply that serves 10 or more families or 25 or more persons daily or has at least 10 service connections at least 60 days out of the calendar year. (36.21.634(29)ARM)

There are two types of public water systems, community and noncommunity. A community public water system is one that serves residents (in towns, subdivisions, trailer courts, etc.), and noncommunity public water systems are those that serve the public, through nonresidential taps, (such as cafes, campgrounds, bars, etc.).

All plans and specifications for construction or modification to community systems must be prepared by a registered professional engineer. Plans and specifications for noncommunity systems can be prepared by anyone knowledgeable in the field (water well contractors, plumbers, engineers, sanitarians).

Because of several recent complaints where prior approval was not obtained, it is important that these rules be followed and the well owner informed of the requirements which must be met. If you have specific questions regarding the laws or regulations on public wells, please call the Water Quality Bureau in Helena at 444-2406.

Board of Water Well Contractors Members

Robert N. Bergantino, hydrogeologist and research associate professor, is the new member representing the Montana Bureau of Mines and Geology. The Water Well Contractors Law requires a hydrogeologist member from the Bureau. Bob was born in Glasgow, Montana. He attended college at the North Dakota State School of Science in Wapheton, North Dakota and received an Associate of Science degree in 1960. He also attended the University of Montana in Missoula and received a Bachelor of Arts degree in 1967.

Bob served in the United States Navy and was discharged in October of 1964. Bob is married to Sharon and they have one son, Tony, who is a freshman in computer science at Montana Tech. Prior to going to work for the Bureau in 1974, Bob was a geologic oceanographer for the U.S. Naval Oceanographic Office, where he started in June of 1968.

Bob's research interests include fluvial and glacial geomorphology, sediment depositional processes, remote sensing applications to geology and hydrogeology, climatology, climate and weather modification, cartographic methods of data presentation, and historical cartography.

His hobbies and other interests are photography, painting, drawing, calligraphy, map-related historical research, fishing, hiking, and skiing.

Bob has authored or co-authored more than 60 publications relating to geologic and hydrogeologic maps.

A Short Course in Hydrogeology

Groundwater Geology
(as it relates to water well construction)

Identification of Earth Materials

One of the most important parts of a well driller's report is the geologic log. The information in a log is used by geologists, engineers, well drillers, and governmental entities in interpreting underground formations.

Geologists have divided earth materials into many detailed subdivisions. For our purposes, a few general subdivisions are sufficient. Earth materials may be separated into consolidated and unconsolidated categories. Unconsolidated formations are naturally occurring, loosely cemented or poorly hardened earth materials including such materials as uncompacted sand, silt, and gravel. Consolidated materials require further explanation (see Table 1). These materials can be divided into three main headings: sedimentary, igneous, and metamorphic.

Sedimentary rocks are present throughout most of eastern Montana and in many of western Montana's intermountain valleys. Those rocks include conglomerate, sandstone, siltstone, shale, and limestone. Sediments are typically deposited one layer on top of another, and the layering that results is called bedding. When a rock is composed of cobbles and gravel cemented together so that it does not easily break with a hammer or cut with a drill, it is called a conglomerate. Sandstone consists mainly of particles of sand cemented together by pressure and solutions. Siltstone is a finer grained equivalent of sandstone. This type of rock seldom forms a good aquifer. Shale is composed of clay-size particles cemented together and is also usually a poor aquifer material. This rock is thinly bedded with a wide range of colors but is usually blue, black, or red. Limestone consists of very fine particles of calcium carbonate cemented together, which formed in ancient sea bottoms millions of years ago. Since limestone reacts to weak acid solutions, it often results in the formation of cavities and channels which make good aquifers. Since this rock type is easily confused with claystone or siltstone, an HCL acid test will readily cause the rock to fizz, identifying it as a limestone.

Igneous rocks are those formed by molten material which is forced up from great depths within the earth. Some of this molten material reaches the earth's surface, erupts as lava, and cools to form volcanic rock such as rhyolite and basalt. These are often buried under successive layers of lavas or sedimentary rocks and are not always evident at the surface.

Extensive areas of volcanic rock are exposed along the upper Yellowstone and Madison rivers of southwestern Montana and in the upper Clark Fork basin of west central Montana.

Other molten material cools before reaching the surface and forms such rocks as granite and diorite. These may remain buried or may be exposed at the surface after long periods of erosion. Granite rocks are often considered to be "basement rocks." Generally speaking, if you drill into granite you are not likely to drill through it. Erosion has exposed areas of granitic rocks in most of Montana's mountain ranges.

Metamorphic rocks are those rocks which have been changed in form due to heat, pressure, and often by movement, or by all three. These rocks are present throughout much of western Montana. Quartzite is a sandstone composed primarily of fine-grained quartz fused together by heat and pressure. It has a sugary appearance and feels rough to the tongue. Slate and argillite are both terms for metamorphosed shale. Both are

harder than shale; shale has a very platey appearance. Marble is a metamorphic equivalent of limestone. Gneiss is a granite or sedimentary rock which, when transformed by heat and pressure, has a banded appearance because the original minerals of the parent rock have been forced into alignment.

Metamorphic rocks normally act as aquifers only where they have been fractured; wells drilled in such rocks will derive water from the fractures themselves rather than from the body of the rock.

Several items are important when describing earth material in a well log. Carefully note the (1) rock type, (2) color, (3) hardness, (4) size of particles. This is the order in which you should describe the rock in the well log. Example: Basalt, red, hard, fractured, water-bearing.

TABLE 1

Consolidated Rocks

Sedimentary

Rock Name	Composition	Physical Characteristics
Conglomerate	Cemented cobbles, gravel, sand, and sometimes silt.	Color varies. Very uneven composition. Hardness varies widely with the degree of cementation.
Sandstone	Cemented sand. Contains varying amounts of silt, mica, or other materials.	Buff, yellow, brown, and gray in color. Drills fairly well except where it is highly cemented. Deposited in layers of varying thickness. Water bearing characteristics vary widely.
Siltstone	Cemented material of silt size.	Layered, generally gray in color. Forms gritty mud when drilled.
Shale	Compacted and cemented clay.	Thinly layered. Often blue, gray, green, or yellow in color. Drills easily, and often the cuttings exhibit thin soft flakes. Poor aquifer.
Limestone	Compacted and cemented limy mud.	Thin to thickly bedded. Generally light to dark gray in color. Rock will fizz when weak hydrochloric (muriatic) acid is put on it. Very good aquifer when solution channels have formed.

Igneous

Rock Name	Physical Characteristics
Granite	Generally light to dark gray or pinkish in color. Mineral crystals are well developed and generally even in size. Very hard to drill. Groundwater occurs in joints and fractures in the rock.
Rhyolite	Gray, white, red, or purplish in color. Often highly fractured. Contains grains of quartz, mica, and sometimes pumice fragments. Often associated with obsidian flows. Fairly hard and slow drilling with much abrasion of drill bits.
Basalt	Usually dark gray to black in color. Generally well jointed and often includes small green crystals of olivine. Gas bubbles are present near the top and bottom of individual flows, and contacts are generally marked by cinder beds, thin deposits of sediments, and reddish discolorations. Where the pore space exceeds the rock material, the rock is called scoria.

Metamorphic

Rock Name	Physical Characteristics
Quartzite	A light colored, extremely hard sandstone consisting almost entirely of quartz grains. This is probably the hardest rock to drill.
Argillite/ Slate	Both refer to metamorphic equivalents of siltstone or shale. Harder than shale, slate plate-like in appearance.
Marble	The metamorphic equivalent of limestone. Generally light gray in color with darker contorted bands.
Gneiss	Granitic appearing rocks. Generally darker in color with a banded appearance. Very hard to drill. Water occurs only in joints and generally in small amounts.

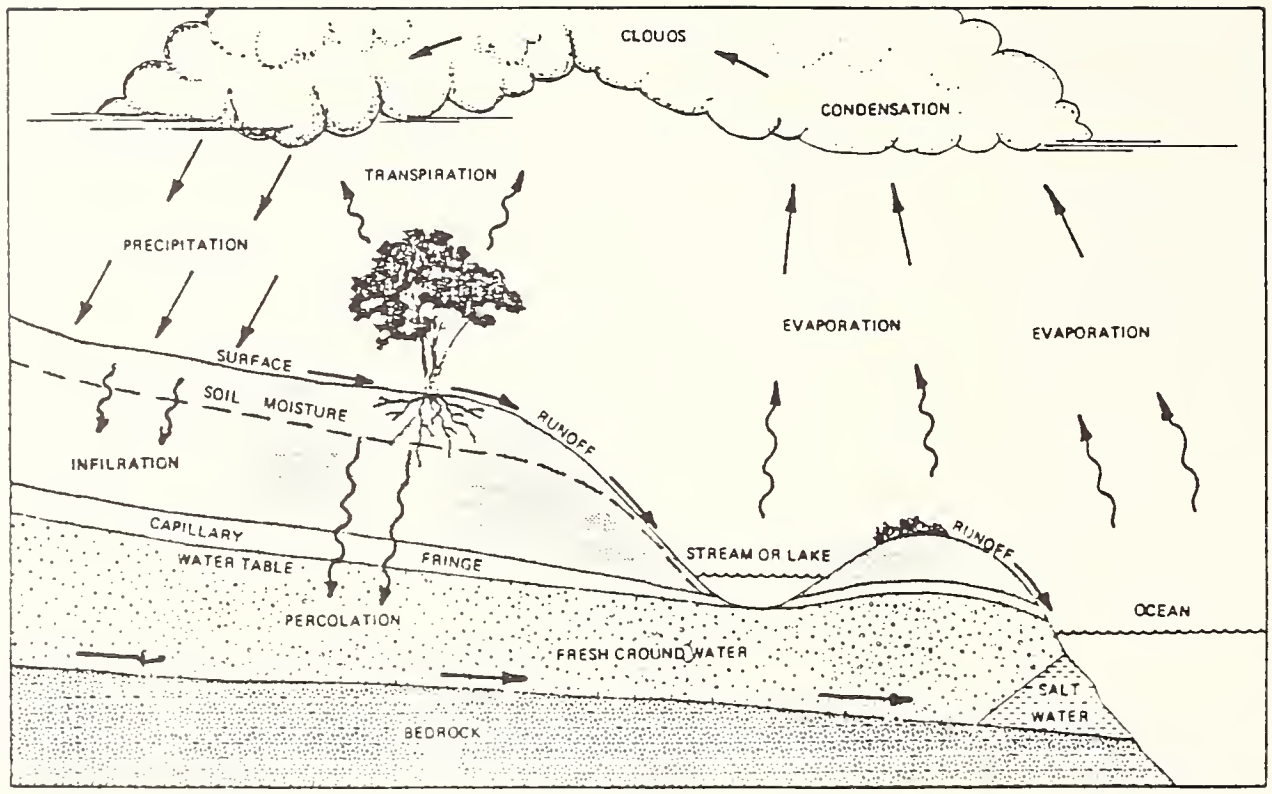

Figure 1
THE HYDROLOGIC CYCLE

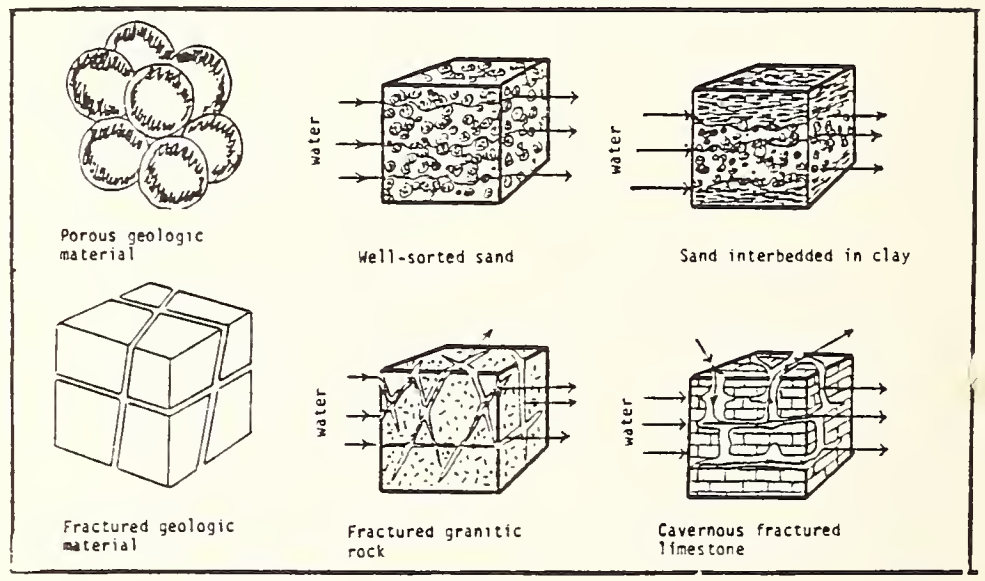

Figure 2
TYPES OF VOID SPACE
IN GEOLOGIC MATERIALS. (ADAPTED FROM HEALTH, 1982).

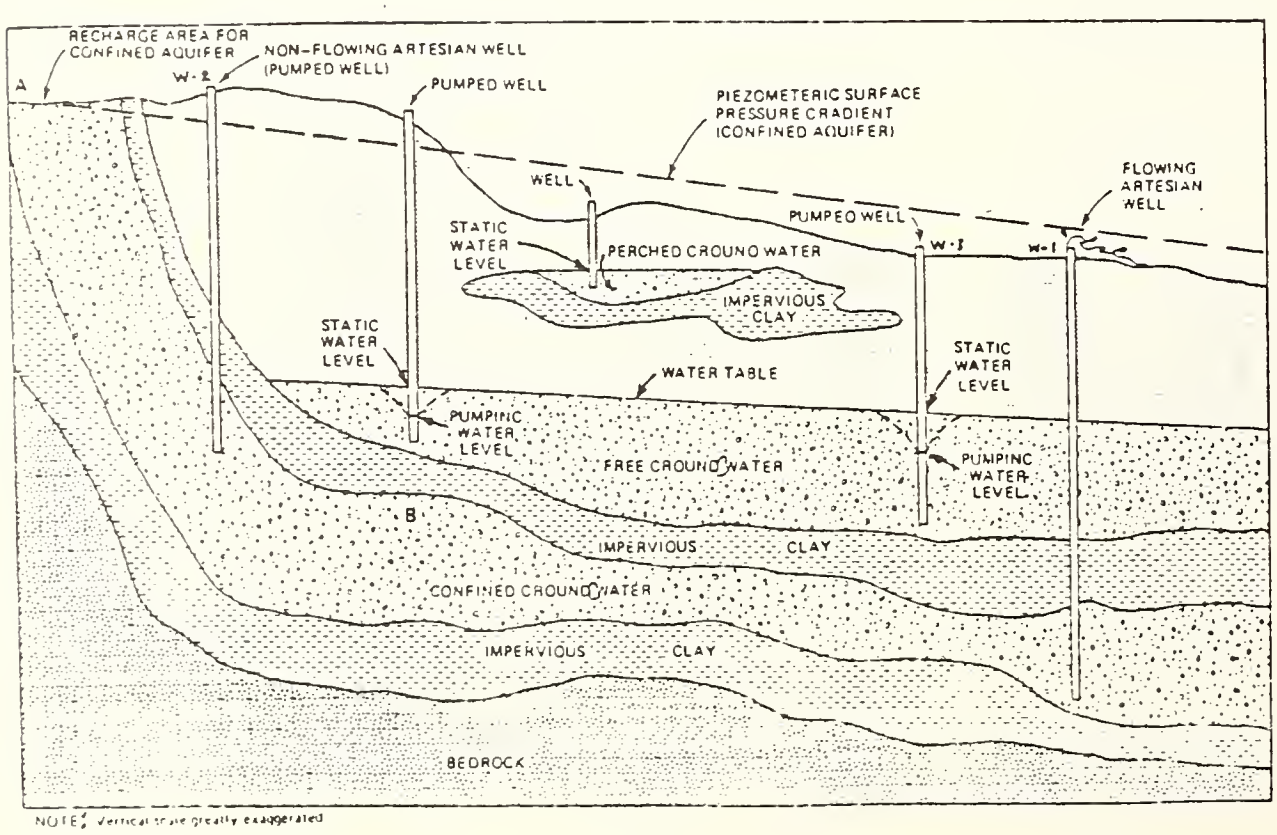

Figure 3
CROSS-SECTION SHOWING FREE, CONFINED, AND PERCHED GROUNDWATER CONDITIONS

Geological material. "Geological material" means all materials penetrated in drilling a well.

1. The following table lists materials other than consolidated rock classified according to average particle size (Wentworth 1972).

Material	Particle Diameters Millimeters	Inches
Clay	Up to 0.005	Up to 0.0002
Silt	0.005-0.062	0.0002-0.0025
Fine Sand	0.062-0.250	0.0025-0.010
Medium Sand	0.250-0.50	0.010-0.020
Coarse Sand	0.50-1.00	0.020-0.040
Very Coarse Sand	1.00-2.00	0.040-0.080
Fine Gravel	2.00-4.00	0.080-0.160
Coarse Gravel	4.00-62.5	0.160-2.50
Cobbles	62.5-250.0	2.50-10.0
Boulders	250.0 & larger	10.0 & larger

2. "Alluvium" is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during recent geologic time by a stream or other body of running water as a sorted or semisorted sediment.

3. "Glacial drift (unconsolidated)" is a general term applied to all rock material (clay, sand, gravel, and boulders) transported by a glacier and deposited directly by the ice or by water running directly from the glacier.

4. "Glacial outwash" means a stratified sand and gravel removed or washed out from a glacier by meltwater streams and deposited in front or beyond the terminal moraine or the margin of an active glacier.

Groundwater Hydrology

Groundwater is part of the earth's water circulation system. This system is called the hydrologic cycle. Figure 1 shows the primary features of this cycle. Water evaporated from the ocean basin is transported as water vapor in the air. It then falls on the land as rain or snow. Part of the rain or snow runs off in streams, part is evaporated, and part percolates into the ground and becomes a portion of the groundwater system. The groundwater flows down gradient under the force of gravity and discharges either to springs or lakes or newly developed wells. The movement of groundwater is extremely slow under most conditions.

Groundwater occurs in permeable geologic formations known as aquifers. To support a well, an aquifer must be able to transmit or allow movement of groundwater. Many geologic formations may act as aquifers. These include gravel and sand, sandstone, and limestone. Other formations, composed of clay, silt, and shale do not ordinarily make good aquifers.

Solid granite and metamorphic rocks do not contain or transmit very much water; however, groundwater may be found in these rocks where they are highly fractured or decomposed.

Groundwater occurs in the open area or pores in soil or rock. Figure 2 shows the open area or voids available for groundwater flow in several types of geological formations. In hard or consolidated rocks, the water is transmitted through fractures, joints, and solution openings between individual grains or particles. The amount of water transmitted in a geological formation depends on the interconnection of the pores, cracks, or openings in the material. Groundwater is transmitted under the force of gravity, much like a rock rolling downhill. The speed at which groundwater travels is controlled by the slope of the material holding the groundwater and the ability of the aquifer material to transmit water.

There are two major types of aquifers. One is the water table or unconfined aquifer, the other is the confined or artesian aquifer. The water table aquifer (see Figure 3) is supplied and constantly recharged through infiltration to the groundwater system and is not controlled by confining strata. At well Number 3 in Figure 3, the well driller first encountered water at 30 feet below land surface and the water stood at that level. The confined or artesian aquifer (see Figure 3) is recharged by water entering at Point A. It then travels by gravity downward under the confining layer at Point B. The confining layer is essentially impermeable. Well No. 1 in the figure was drilled through the upper confining layer. Since the top of the well was lower than the artesian level in the figure, the well flowed at the surface. Well No. 2 was drilled in the same manner as Well No. 1, but because this well was located on a hill with the top of the well above the artesian levels, the well did not flow. The water level in the well was at the artesian level. This is also an artesian well. A well does not have to flow at land surface to be artesian. If the water level in the well rises above the top of the confining layer in which it is encountered, the well is artesian.

In some cases, water is encountered above the general water table. This is called a perched water table (see Figure 3). These aquifers are limited in extent and are not usually reliable aquifers.

Static water level is defined as the level at which water stands in a well that is not being pumped. It is generally expressed as the distance from ground surface (or a measuring point near the ground surface such as the top of the well casing) to the water level in the well.

Drawdown is the difference in levels between the static water level and the surface cone of depression. A useful term in describing the ability of a well to yield water is the specific capacity. The specific capacity is the ratio of the discharge of a well to the drawdown in the well. If a well has a drawdown of 30 feet while being pumped at a rate of 90 gallons per minute, the specific capacity would equal 90 gallons per minute divided by 30 feet, or 3 gpm per foot of drawdown.

For further information on any of the material contained herein contact:
Diana C. Cutler, Program Specialist
Board of Water Well Contractors
1520 East Sixth Avenue
Helena, MT 59620
(406) 444-6643

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1520 East Sixth Avenue
Helena, Montana 59620
(406) 444-6643